A Vision of Traffic Lights for Color-Blind People

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***Abstract* - This paper presents a work in progress and an analysis about the difficulties for color-blind people to recognize traffic lights. Colorblindness (dyschromatopsia or discromatopsia) is a disease characterized by an abnormality in the photosensor pigment cells of the eye, resulting in the malfunction of color detection, most frequently in red and green shades. With this work, we want to understand the main concern about how smart cities will provide an accessible environment for colorblind drivers.**

Keywords - smart city; accessibility; color blindness.

I. INTRODUCTION

Worldwide, hundreds of millions of people have vision problems and color blindness is one of them. In Brazil, 14.5% of the population have some vision disability and 10% have some kind of color blindness [1]. It is a genetic disorder that affects the X chromosome, causing inability to distinguish any primary colors. A color-blind person has deficient cells, resulting in a distorted perception of colors. The most common color confusion is between green and red shades [2].

The lack of standardization of traffic lights generates some difficulties for color-blind people, such as walking and driving or to identifying traffic lights. So, it is possible to identify opportunities for learning and for better management of special needs to accessible and smart cities [3].

Due to fast urban growth, cities now face many risks and an urgent need to find smarter ways to manage challenges such as adopting solutions and including disabled people [4][5]. The study contained here is an effort to identify and analyze traffic lights problems and how it could be used to create better solution to color-blind drivers.

The paper is structured as follows: Section I is the introduction of this study. Sections II and III are a review of the literature about color blindness. Section IV is research description and methodology and section V the research results. Finally, in Section VI there are conclusions and proposals for future works.

II. COLOR PERCEPTION AND BLINDNESS

Retinal cells, called cones, are responsible for the perception of colors. There are three kinds of cones and each one is responsible for the colors red, green and blue, known as basic colors and the other colors are a combination of those three colors. Color perception is a sensorial process that gives meaning to objects and environment lights through the use of memory to convert colors into sensations [1][2]. Therefore, for the colors to exist, we need two main elements: eye and light. An important factor to decode colors through the eye is the wavelength, since human visual perception is a sensation [6][7][8] and the white color is not considered a color, just a sum of all colors. The maximum spectrum of light sensitivity to give wave range are the colors yellow, green and blue [6][7][9]. The most common symptoms of color blindness are the problems to identify color brilliance and nearby colors [10][11]. Color is a fundamental part of visual communication. The meaning of colors can be covered in many aspects in society - it is common to use color as a direct reference to qualify objects, based on the guidelines of traffic lights, the red light means the driver needs to stop and green light means to go.

Color blindness is a cone cell deficiency that changes color perception; it is a problem that affects about 10% of the world population. Color blindness is a genetic problem with the X chromosome and it is more frequent among men with only one X chromosome, while females have two X chromosomes.

The degrees of dyschromatopsia are variable and they are classified into four categories: Protanopia, the most common, which is the inability to distinguish between red and green shades, deuteranopia, a confusion of red and green shades, tritanopia, a conflict between blue and yellow shades, and achromatopsia, a total blindness to other colors, providing a black and white vision.

One of the most common ways to discover color blindness ID is applying the Ishihara test [5]. This test consists of 32 colorful cards with various circles with a different hue, saturation and brightness in the same board [2]. Unfortunately, there is no solution to correct color blindness and people usually learn how to live with the problem.

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III. COLOR BLINDNESS AND TRAFFIC LIGHTS

Driving may not be the most difficult activity for color-blind people. Nowadays, there is no evidence of traffic infractions by color-blind people. This particular situation demands a reflection about the relationship with traffic signs and lights for colorblind people. A colorblind person has the ability from visual perception about shapes and textures; so, no matter what traffic sign colors shown, a colorblind person will have no difficulty to understand color meaning.

Many types of colors and cards do not represent an obstacle to understand the messages as long as it follows a previously known pattern.

However, traffic lights must be considered a problem because they do not have an established standard. Many traffic lights do not have colors vertically distributed using the red light on top, yellow in the middle and green at the bottom. This lack of standardization contributes with the inability of color-blind people to understand traffic lights. Perception of green and red colors is the biggest problem for people with this disability. Some cities have already adapted accessible traffic lights. Most of the adapted traffic lights have a white band by the side of the yellow light, allowing the color-blind to distinguish a color signal by the illumination and position of the light. Some cities use horizontal traffic lights with the red light on the left and the green light on the right. If a color-blind guides himself by which side each color is, he will probably mix them all.

IV. METHODOLOGY

Based on a research with young color-blind drivers, data production was carried out between December 2014 and February 2015. The population of the study was composed by 14 male participants, from 18 to 40 years old, recruited and invited to participate in the study. They answered questions about driving in attention to mobility and accessibility in streets and avenues.

The objective of the survey was to identify problems with disordered and chaotic traffic signs and possibilities to solve urban problems. Questions were developed to help in the comprehension of the problem:

a) What mean of transportation do they use?

b) Do they feel any difficulty to identify traffic lights while driving?

c) How often do they drive?

d) How do they understand traffic lights?

e) What do they think about the traffic lights of the city?

Through survey, we first obtained information about how often the volunteers drive, which routes they take and their perception about traffic lights. Then, in order to identify color blindness, all volunteers were submitted to the Ishihara test, the most effective tool for color blindness detection in red and green shades, the most common kind [11]. For this study, we used a version with 24 plates to distinguish defects in the red-green axis. To confirm color blindness, volunteers must at least, fail in eight of the 24 plates. All the recruited failed in the test, confirming the presence of the disability. Through data collection, a semi-structured interview allowed a deep knowledge of users personal meanings about traffic lights.

To build the set of common data, all responses were transcript to use in future works. Analysis of content from interviews and data interpretation and convergent aspects of responses had a thematic categorization.

V. RESULTS

The research revealed that 70% of the volunteers have problems with the lack of standardization in traffic lights. Data showed that in order to improve contrast, it is essential to increase traffic light visibility. For 15% of the respondents, LED (light emitter diode) traffic lights create more difficulty to identify colors because of their excessive luminosity; focusing on LED lights is more difficult, especially at night. The radiation of bright lights might confuse users. When a color-blind person drives at night there is a risk of not identifying which shining light is up or down. In developing countries as Brazil, the biggest limitation for color-blind people is a prohibition to drive. According to the Brazilian law, Resolution No. 80 on 11/19/98 of the National Traffic Council, an ophthalmological evaluation is required (art. 1, Annex I, item 2.1, a) and it demands full color vision (item 3.3.4). Brazilian Traffic Council statement says: "the candidate must be able to identify the colors red, yellow and green" (item 3.8.1). In developed countries, it is quite different. Some European cities have adopted the first color letter matching its correspondent light. It is possible to match each color with different geometric shapes.

The most frequent answer to the survey was that 87% of the volunteers did different moves when they had doubts related to the color light. In some cases, the driver follows other drivers nearby when they do not know which color the traffic light is. We also found that when the carrier of the disability cannot identify the color of the traffic lights, there is a reduction of the speed until he reaches the semaphore. When meeting an intersection, color-blind people tend to stop and wait for another car to cross the roads. In critical cases, color-blind people do not feel safe driving alone; in this case, they always go with friends or family, so that they can assist them in the traffic.

VI. CONCLUSION AND FUTURE WORK

This research sought to understand difficulties of color-blind people and their relation to traffic signals. Distinct solutions were identified and each possible potential benefit will be shown in a future work. Even defining research questions and protocol beforehand, strict validation, especially related to the solution of problems, will benefit future research efforts. The lack of standardization of traffic

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lights must be an urgent subject to propose to governmental institutions.

However, it is important and relevant for this work to continue this research and propose relevant alternatives to improve accessibility for color-blind people - using technology to provide smart solutions such as identifying traffic signals and others, not only based on colors but on more accessible and adaptive ways for people with vision problems.

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